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Wood Preservative Residues in Soil Prendiville Wood Preservers Ltd. Neepawa, Manitoba 1985

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WOOD PRESERVATIVE RESIDUES IN SOIL PRENDIVILLE WOOD PRESERVERS LTD., NEEPAWA, MANITOBA 1985

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ABSTRACT

Soils were sampled at 31 locations on the Prendiville Wood Preservers Ltd. property at Neepawa, Manitoba in 1985 to determine the distribution of copper (Cu), chromium (Cr) and arsenic (As) from CCA preservative solution. Two depths, 0-5 cm and 5 to 10 cm were sampled at each location. Soil was sampled from a background location for comparison. The concentrations of Cu, Cr and As in the surface soil (0-5cm) were highest close to the transport rails and the main doorway to the treatment building and decreased with distance in all directions. Levels of Cu, Cr and As were lower in the 5-10 cm soil layer but were still above background at some locations. Elevated concentrations in ditches along the property boundary indicated that preservative contaminants may be migrating off-site.

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1. INTRODUCTION

The service life of wood can be significantly increased by impregnating it with chemicals which are toxic to wood boring insects and decay fungi. Fence posts, utility poles, railway ties, bridge timbers and more recently dimension lumber and plywood for wood foundations, decks and fences are now treated with wood preservative chemicals.

Prendiville Wood Preservers Ltd. has operated a post and lumber treatment plant at Neepawa, Manitoba since 1979. The process involves pressure treatment of the wood with CCA, a water-based solution of chromated copper arsenate. The pressure treatment cylinder is a long cigar shaped cylinder lying on its side with a removable end closure. The wood is moved into the cylinder on dollies travelling on transport rails. When the dollies are loaded, and rolled into the cylinder, the door is closed and bolted tightly to withstand vacuum and pressure. Treatment involves applying a vacuum initially, followed by flooding the cylinder with CCA preservative solution and applying pressure. After the prescribed treatment time, surplus preservative is pumped back to the mixing tank and vacuum is applied to assist with the removal of excess solution from the surface of the treated wood. The rail dollies are rolled out of the treatment cylinder and the freshly treated wood is transferred to the storage yard. Preservative drips from the freshly treated wood for 48 hours or more after removal from the cylinder. Contamination of soil can

occur along the transport rails leading from the treatment cylinder and in areas of the yard where the freshly treated wood is placed to air dry.

The objective of this study was to determine the degree and extent to which the soil of the storage yard has been contaminated with copper, chromium and arsenic residues from the preservative.

Few studies of soil contamination at CCA facilities have been reported in the literature. One site on the banks of the Fraser River in the lower mainland of British Columbia was studied to determine the nature and degree of cleanup required after the plant closed (Henning and Envirochem 1984). Arsenic and Cr were elevated in soils on that property and As had leached into the groundwater. Another report documents contamination of groundwater by CCA chemicals at a treatment plant in California (Cohen 1987). Although some soil analyses were done in conjunction with these studies, the data are limited. Monitoring of soil at Roblin Forest Products, Roblin, Manitoba, was carried out in 1983 (McEachern and Phillips 1985). Concentrations of Cu, Cr and As in the surface soil at Roblin were highly elevated since contamination had been occurring over a period of 19 years.

2. METHODS

Thirty-one sampling locations were selected within Prendiville Wood Preservers Ltd. property (Figure 1) and a control was located 1.5 km north. Sites were located along 7 transects radiating from the main loading door of the treatment building. Within 60 m of the building, the sampling locations were spaced 25 m apart and beyond that the spacing was increased to 50 m. Some samples were taken from drainage ditches within the property and along its NE boundary.

Two samples were taken at each location, a surface sample (0-5 cm) and a subsurface sample (5-10 cm). A stainless steel trowel was used to remove the sample. In hard-packed areas, a pick was used to loosen the soil so it could be sampled. In those cases, the surface layer was loosened first and removed and then the subsurface layer was loosened and sampled. Each sample was placed in a new plastic bag which was in turn sealed by tying the top. Samples were placed in a cooler with a freeze pack and were transported to Winnipeg where they were frozen. Prior to analysis, the samples were air dried and ground by mortar and pestle to pass an 80 mesh sieve.

The samples were analyzed for copper, chromium and arsenic by atomic absorption spectrometry at the W. H. Ward Technical Services Lab, Manitoba Environment and Workplace Safety and Health.

Coordinates were determined for each sampling location by overlaying the site map with graph paper (10 line per inch grid). These sample coordinates and the Cu, Cr and As concentrations were analyzed with a G3GRID computer program (SAS 1985) to determine (by

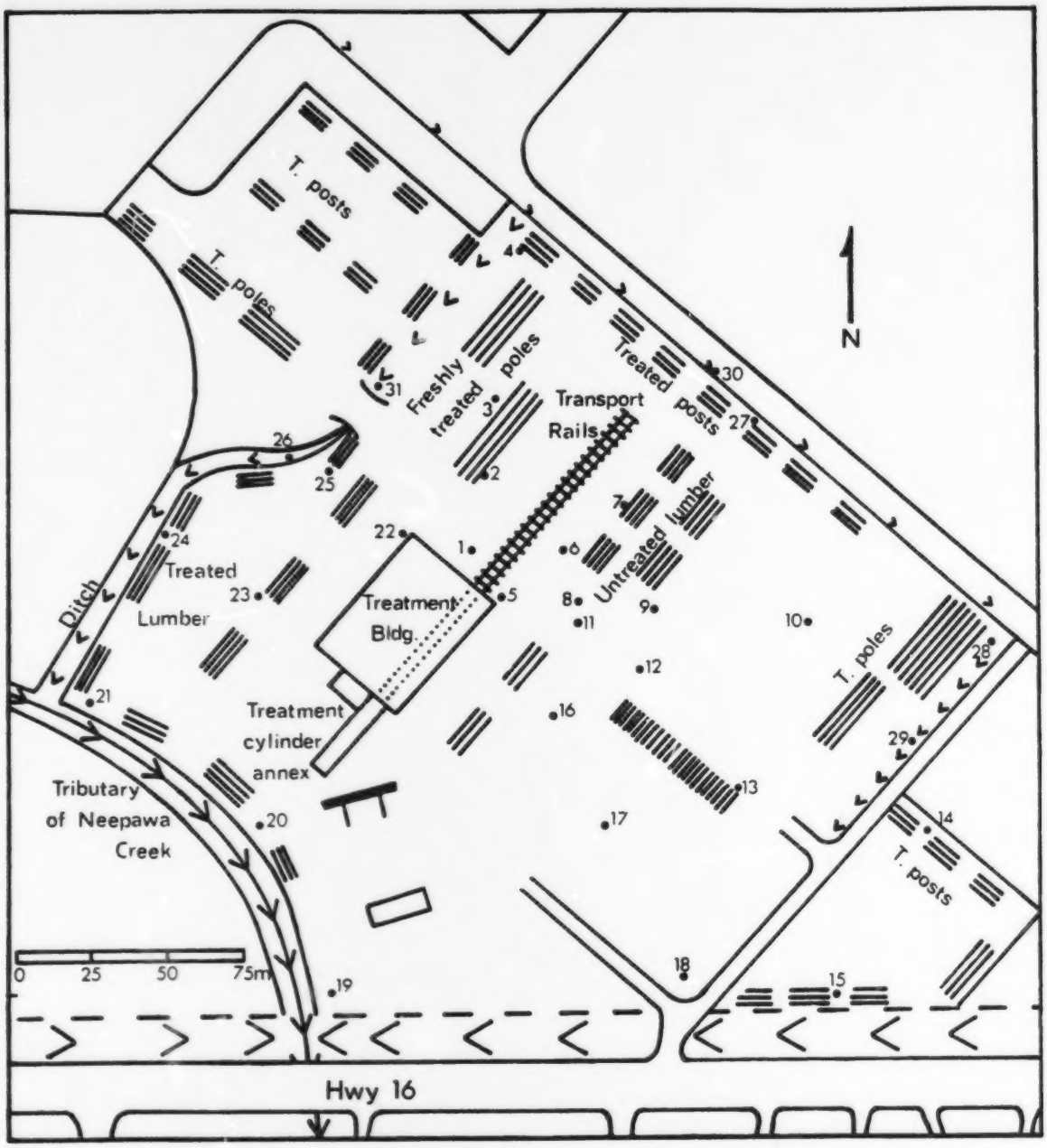

Fig.1 : Site map of Prendiville Wood Preservers Ltd. Plant, Neepawa. Manitoba.

interpolation) the concentrations at all grid coordinates within the property. Isopleth lines of equal concentration were drawn using a SAS/GRAPH procedure called GCONTOUR (SAS 1985).

3. RESULTS AND DISCUSSION

3.1 Surface Soils

Concentrations of Cu, Cr and As in the surface and 5 to 10 cm soil layers are presented in Table 1. Isopleth lines showing the concentrations of each element (Cu, Cr and As) in the surface soil are overlayed on a simplified map of the Prendiville property (Figures 2, 3 and 4).

At the Prendiville site in Neepawa, Cu, Cr and As have accumulated in high concentrations in the yard NE, N and NW of the treatment building. The freshly treated wood is usually placed in that area immediately after being taken out of the treatment cylinder. The concentration was highest at site 1 which was close to the main door and also adjacent to the transport rails. The Cu concentration at site 1 was 865 µg/g while that of Cr and As were slightly lower at 653 µg/g and 641 µg/g respectively (Table 1). Although no sampling was done within the treatment building, concentrations were probably high there as well. The concentrations decreased with distance away from the transport rails and the main door into the treatment building. Concentrations of Cu, Cr and As in the surface soil were higher than at the control site (Cu:15 µg/g; Cr:10 µg/g; As:5 µg/g) indicating that there was some contamination over the entire Prendiville property. Although the

Table 1: Concentration (µg/g) of copper, chromium and arsenic in the surface soil and in the 5 to 10 cm soil layers at each sampling site on the Prendiville Wood Preservers Ltd. property.

Site	Surface (0-5 cm)			Subsurface (5-10 cm)		
	Cu	Cr	As	Cu	Cr	As
1	865	653	641	108	101	85
2	214	158	167	46	46	38
3	577	435	415	52	43	30
4	304	240	226	31	34	19
5	433	336	425	34	53	36
6	448	365	410	180	173	176
7	597	557	479	24	29	25
8	391	586	649	46	41	35
9	328	293	306	31	36	21
10	132	123	94	21	19	9
11	317	245	268	216	202	165
12	185	154	130	24	29	15
13	175	154	125	19	14	11
14	36	48	19	19	17	5
15	147	154	85	19	19	8
16	206	149	166	31	27	17
17	122	104	96	19	14	7
18	62	62	60	19	12	8
19	19	10	11	15	12	5
20	93	53	46	15	17	8
21	165	96	92	15	10	17
22	391	302	262	36	82	26
23	185	178	362	19	19	11
24	34	27	24	15	10	5
25	361	240	274	26	22	17
26	546	432	267	13	12	6
27	230	216	162	15	12	7
28	173	166	123	24	17	7
29	567	451	363	21	19	146
30	266	211	163	21	41	26
31	427	326	264	N/A	N/A	N/A
Control	15	10	5	15	22	8

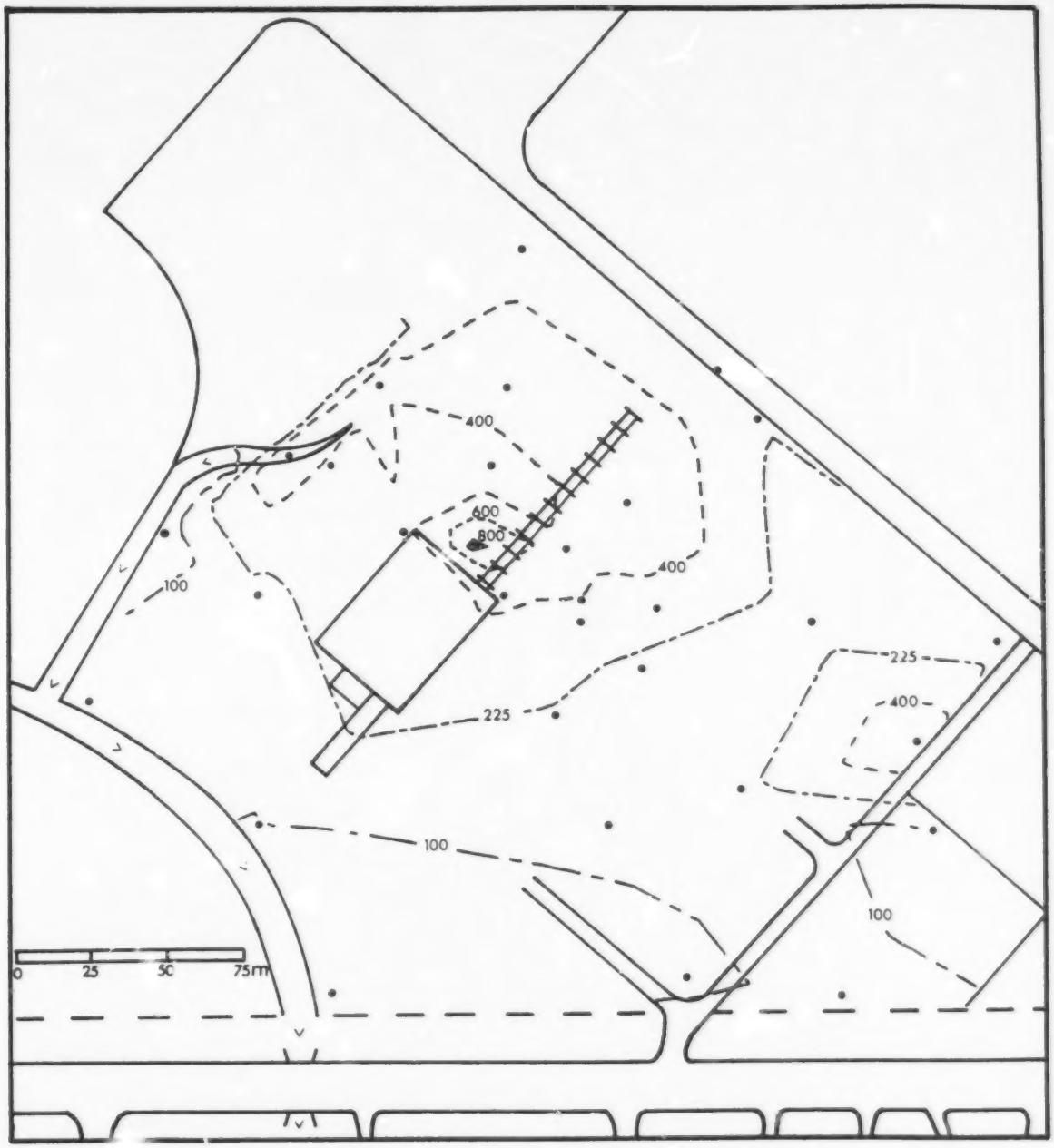

FIG.2: ISOPLETHS OF COPPER CONCENTRATION (µG/G) IN SURFACE SOIL AT PRENDVILLE WOOD PRESERVERS LTD., NEEPAWA, MANITOBA, 1985.

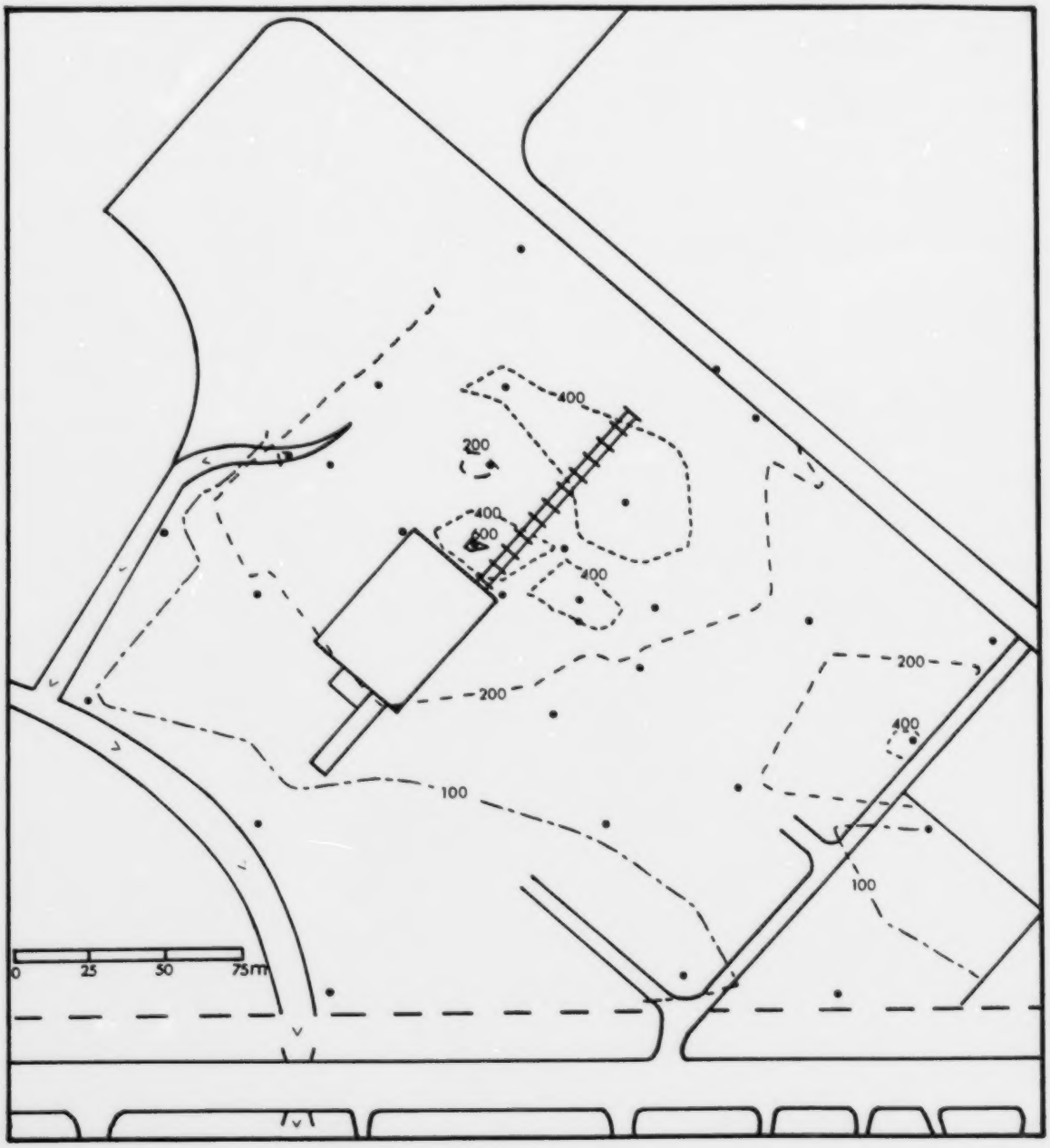

FIG.3: ISOPLETHS OF CHROMIUM CONCENTRATION (µG/G) IN SURFACE SOIL AT PRENDVILLE WOOD PRESERVERS LTD., NEEPAWA, MANITOBA, 1985.

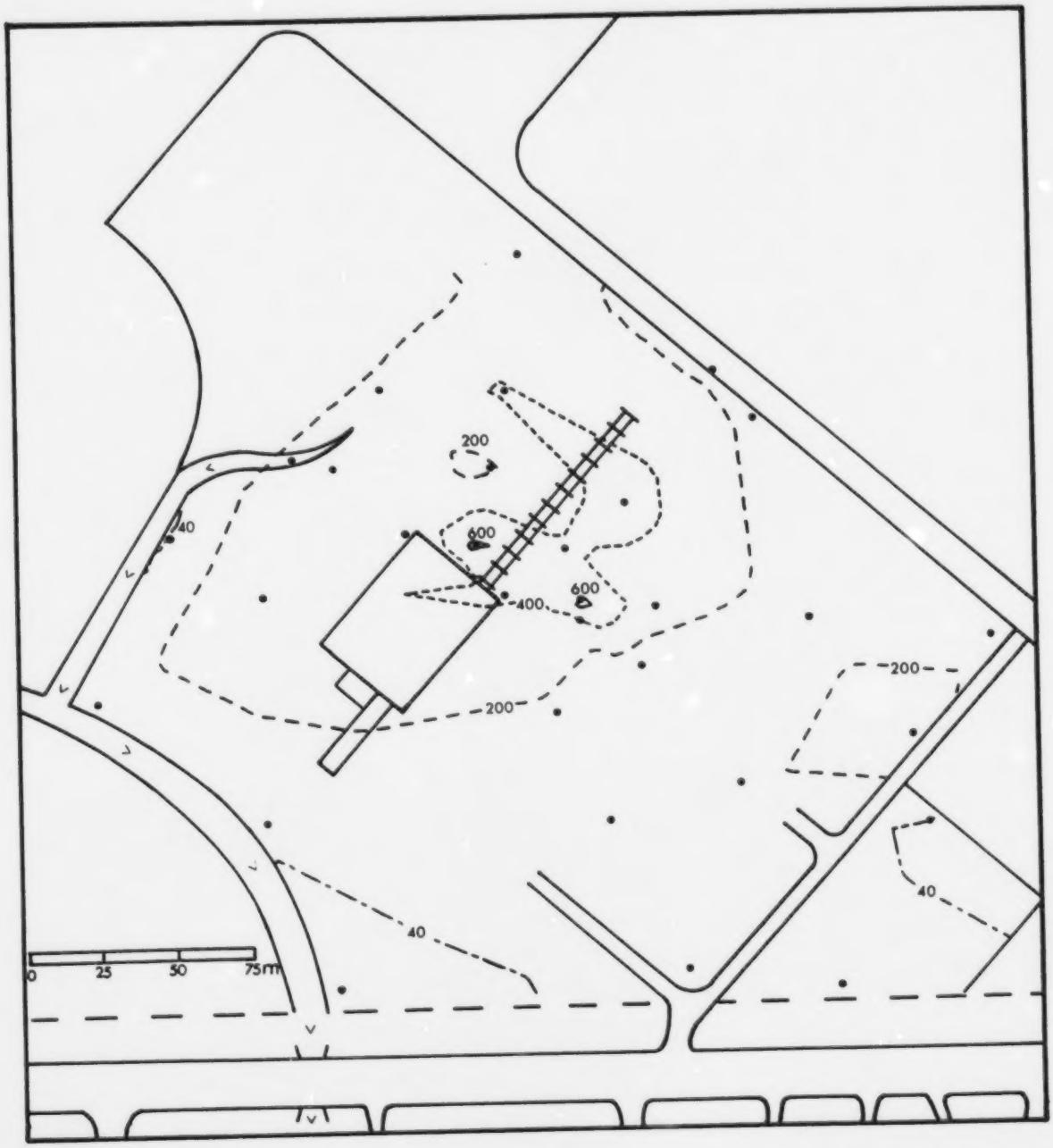

FIG.4: ISOPLETHS OF ARSENIC CONCENTRATION (UG/G) IN SURFACE SOIL AT PRENDVILLE WOOD PRESERVERS LTD., NEEPAWA, MANITOBA, 1985.

primary source of contamination was probably drips of preservative from freshly treated wood, yard maintenance such as grading or snow clearing could have moved some of the contaminated soil to other areas of the yard. Wind and water erosion are other agents which have no doubt moved contaminants to other locations.

There is also evidence that runoff water has transported preservative residues into ditches on the Prendiville property. Ditches along the SE and NE sides of the property as well as the one west of the treatment building have accumulated higher amounts of Cu, Cr and As than at adjacent sites on the property. This indicates that off-site movement via sediment transport has occurred. The western drainage ditch is of particular concern because it connects directly to the headwater of a tributary of Neepawa Creek. Sediments should be sampled from this tributary to determine if (or to what degree) it has been contaminated with Cu, Cr or As.

McEachern and Phillips (1983) reported higher concentrations of Cu (2000 µg/g), Cr (2200 µg/g) and As (6500 µg/g) in the surface soil at the Roblin Forest Products treatment plant. The concentrations at Prendiville Wood Preservers in Neepawa were probably lower because the plant had only operated for 6 years compared with 19 years at Roblin.

In the case of a CCA treatment facility in the Lower Mainland of British Columbia, several of the soil samples had As concentrations greater than 170 µg/g and Cr >200 µg/g (Henning and Envirochem 1984). The maximum concentrations must have been very high because crystals of the preservative were found in the subsoil. Rainfall amounts in the Lower Mainland of British Columbia are high and that

probably promoted lateral transport in runoff water and leaching down into the soil thus reducing surface soil concentrations. Leaching was confirmed because the groundwater was also contaminated with As at concentrations as high as 11 mg/L.

Preservative residues in soil were monitored on a limited basis at the Valley Wood Preserving site in Turlock, California (Cohen 1987). The chromium concentration in the soil was up to 3100 µg/g and the groundwater had a concentration of 115 mg/L before the cleanup began. The subsoil consisted of a heterogeneous mixture of sand, gravel and silt (Dames and Moore 1985) which offers little resistance to leaching and consequently increases the risk of groundwater contamination. Cr VI is not adsorbed strongly to soil which could explain why only Cr was found in the groundwater.

Although a number of sites on the Prendiville property had concentrations many times higher than background, an evaluation of whether or not they are environmentally acceptable is required. Ontario's Ministry of Environment has developed criteria for acceptable concentrations of metals and metalloids which is based on their potential phytotoxicity (Ontario MOE 1986). For commercial/ industrial sites with sandy soils the limits are 225 µg/g for Cu, 750 µg/g for Cr and 40 µg/g for As. Soils of the Prendiville property are characterized by a loamy textured surface layer (25 to 60 cm) underlain by medium sand to gravelly textured deposits with rapid permeability (Manitoba Department of Municipal Affairs 1976). Sixteen of 31 surface soil samples from Prendiville had copper concentrations

higher than the limit, while the As limit was exceeded at 28 of 31 sites. Although the criterion for total Cr was not exceeded, a more serious environmental threat, Cr VI may have been overlooked. Dames and Moore (1984) found that in some soil samples, most of the total Cr was in the reduced Cr III form while in others as much as 50% or 100% was still in the Cr VI state. It is probable that elevated concentrations of Cr VI are present in soils of the Prendiville property. Because it is mobile (poor soil adsorption) as well as being highly phytotoxic, Cr VI has a very restrictive limit of 8 µg/g in sandy soils.

3.2 Subsurface Soils

Concentrations of Cu, Cr and As in the soil are much lower at the 5 to 10 cm depth (Figures 5, 6 and 7) which suggests that there is good adsorption potential in the surface soil which has limited downward leaching. There were three sample locations with high concentrations of copper in the 5 to 10 cm zone of the soil. These were sites 1, 6 and 11 at 108 µg/g, 180 µg/g and 216 µg/g respectively. Concentrations of Cr and As were also high in those three samples. Since sites 6 and 11 had lower surface concentrations than some of the other sites, the concentrations at the 5-10 cm depth were unexpectedly high. It is possible that those samples may have been inadvertently located where the yard was once rutted and subsequent yard grading has filled the ruts with the more highly contaminated surface soil.

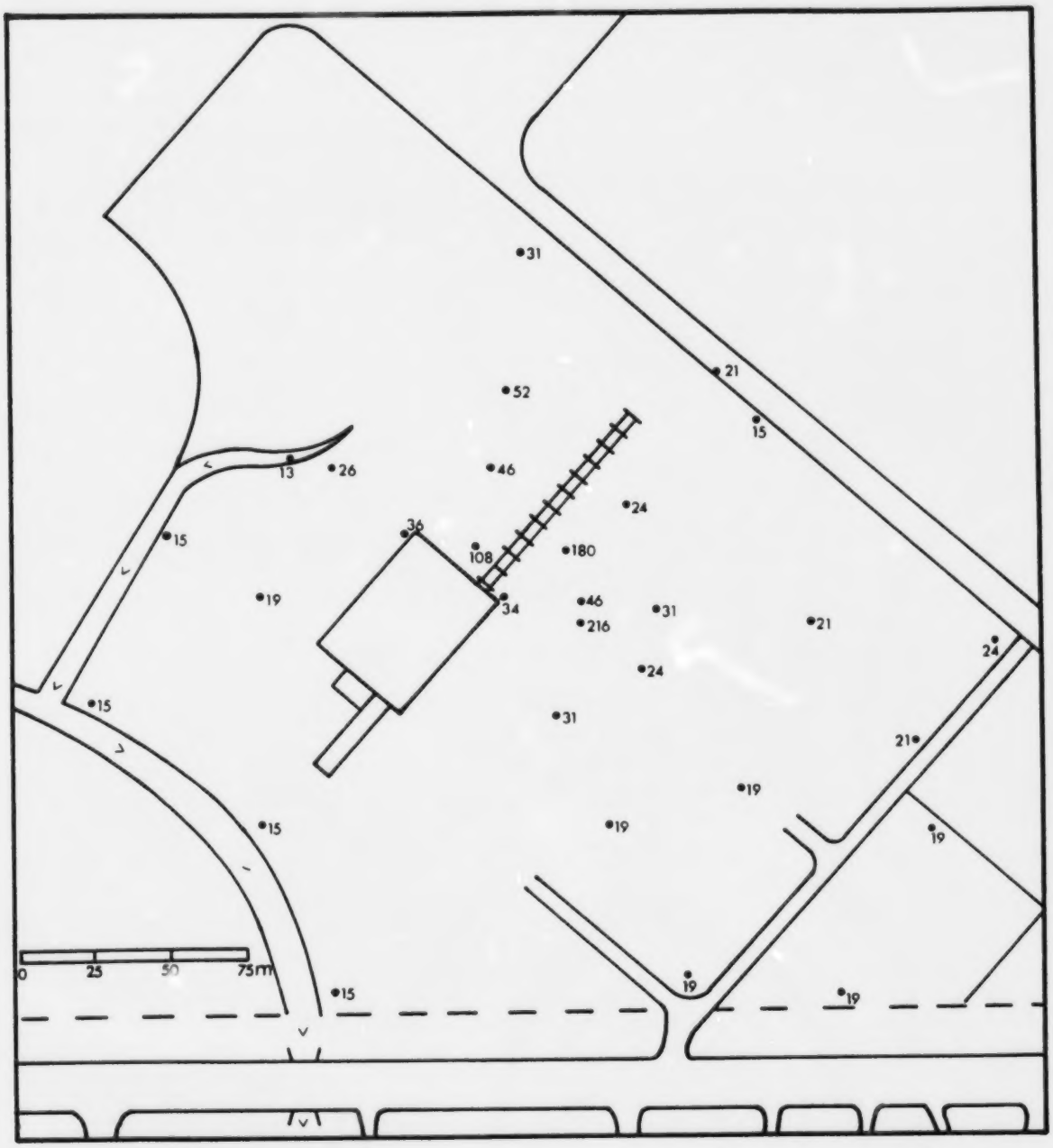

FIG.5: COPPER CONCENTRATION (UG/G) IN 5 TO 10 CM SOIL LAYER AT PRENDVILLE WOOD PRESERVERS LTD., NEEPAWA, MANITOBA, 1985.

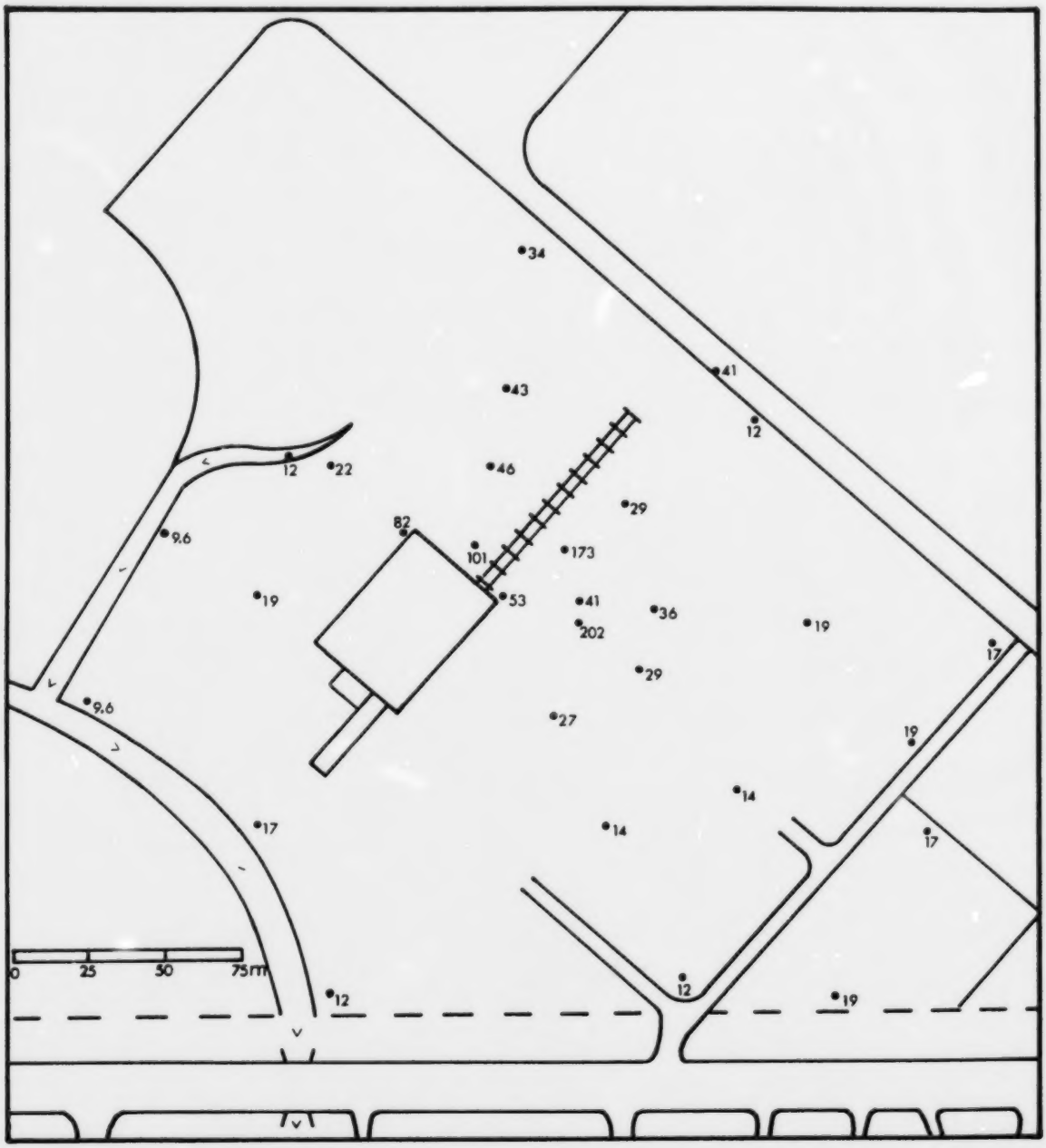

FIG.6: CHROMIUM CONCENTRATION (UG/G) IN 5 TO 10 CM SOIL LAYER AT PRENDVILLE WOOD PRESERVERS LTD., NEEPAWA, MANITOBA, 1985.

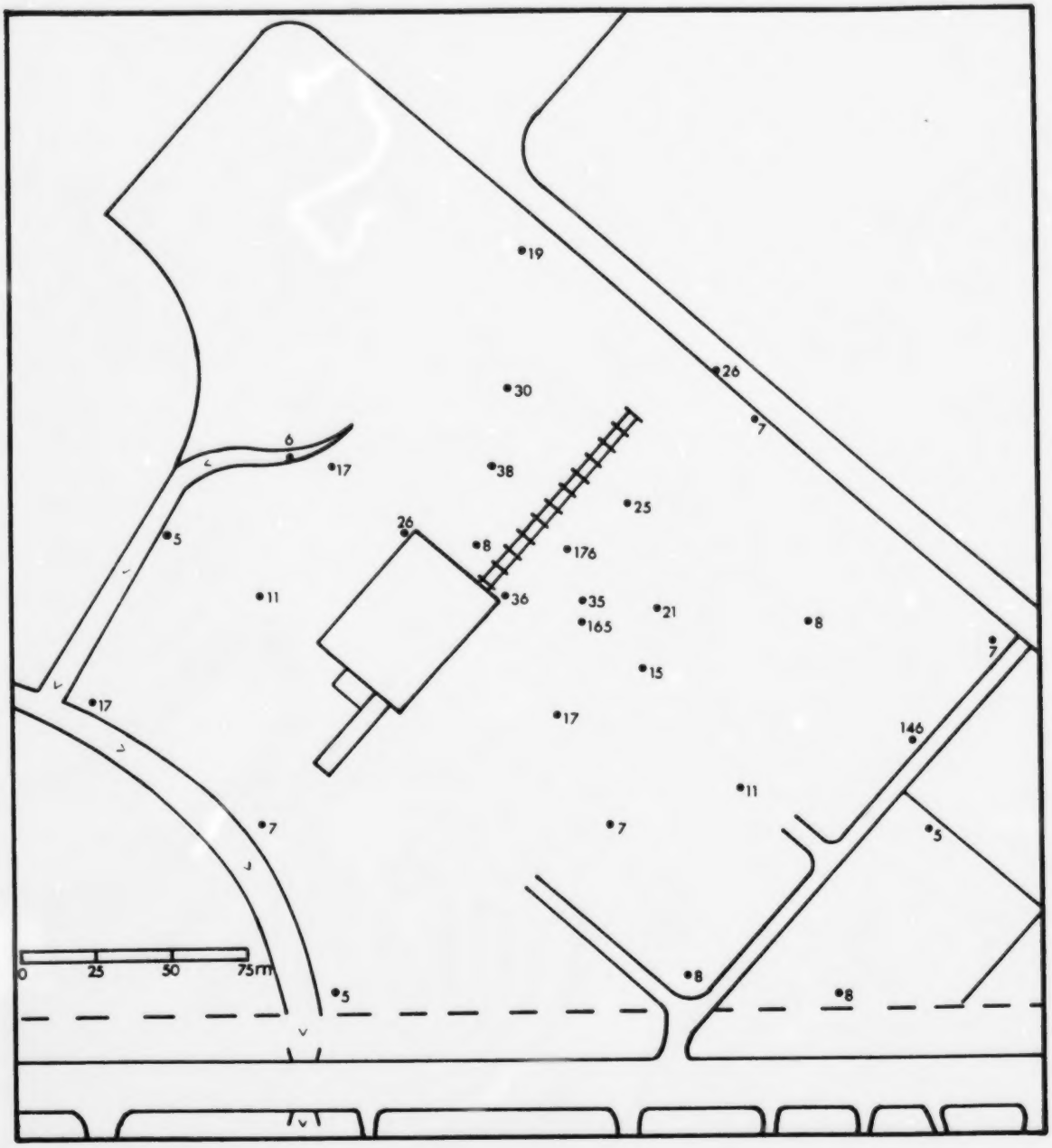

FIG.7: ARSENIC CONCENTRATION (UG/G) IN 5 TO 10 CM SOIL LAYER AT PRENDVILLE WOOD PRESERVERS LTD., NEEPAWA, MANITOBA, 1985.

Although subsurface soil testing has not been done on the property, Neepawa does have a high groundwater pollution hazard rating because of sand deposits close to the surface and also because of a generally shallow groundwater table (Mines, Resources & Environmental Management 1978). The log of a well drilled on the same section (31-14-15W) in 1983 recorded sand from the surface to a depth of 3.7 m (Natural Resources 1983). Many of the other wells drilled on adjacent sections had sand at or near the surface although some did have a layer of clay at the surface. A detailed soil survey of the Neepawa area (Manitoba Department of Municipal Affairs 1976) confirmed that the Prendiville Wood Preservers property has loamy textured surface soils (25 to 60 cm) underlain by sand to gravelly textured deposits. With these soil characteristics there is potential for downward leaching of wood preservative residues and the additional possibility that groundwater might be contaminated. The CCA wood treatment facility in California which caused Cr contamination of the groundwater (Cohen 1987) was also underlain by sand and gravel (Dames and Moore 1985). Detailed subsoil sampling should be carried out at the Prendiville property to determine if leaching is occurring.

3.3 Surface Water

Water samples taken from the tributary of Neepawa Creek had elevated concentrations of Cr (up to 0.30 mg/L) but Cu and As were within the background range. This indicates that Cr was moving off-site while Cu and As were not. Differences in adsorption are the likely cause of this differential movement. Cr in the CCA solution is

hexavalent (Cr VI) which is not readily adsorbed to soil particles (National Research Council 1976). Although reduction of Cr VI to Cr III may occur in soil and water, Dames & Moore (1984) found that some Cr remains in the hexavalent form. It is the hexavalent Cr which has the greater potential to migrate off-site in surface runoff. Cu and As on the other hand have a good adsorption potential and are therefore more resistant to off-site migration. Because of this, Cr VI could appear in off-site drainage while Cu and As would be impeded by adsorption.

Follow up studies should be carried out to monitor Cr III and Cr VI concentrations in the runoff water entering the creek from the Prendiville property. This runoff enters the Whitemud River after flowing a few kilometers in Neepawa Creek. The Whitemud River is an important surface water resource in the region and the amounts of industrial contaminants entering it must be controlled to ensure adequate protection of water quality. Monitoring should be carried out during spring runoff and after heavy rains.

4. CONCLUSIONS

Copper, chromium and arsenic from the wood preservative has accumulated in the surface soil of Prendiville Wood Preservers Ltd. yard at Neepawa, Manitoba.

Maximum concentrations of Cu (865 µg/g), Cr (653 µg/g) and As 641 µg/g) occurred near the transport rails and just outside the main door to the treatment building. Concentrations decreased

with distance away from that location but were higher than background at all sites.

Concentrations of Cu, Cr and As were also elevated in ditches within and around the outside of the property, indicating that off-site migration of the preservative chemicals is occurring.

Potentially phytotoxic concentrations of Cu (225 µg/g) and As (40 µg/g) were exceeded in 50% and 90% of the surface soil samples respectively. The criteria for total Cr (750 µg/g) was not exceeded but it is suspected that Cr VI may be a problem since the limit is only 8 µg/g and the Cr in the wood preservative is in this hexavalent form.

Concentrations in the 5 to 10 cm soil layer were much lower than at the surface which suggests that downward leaching is probably limited. Nevertheless, there is potential for Cu, Cr and As to leach through the soil because the property is underlain by sand and gravelly textured subsoils. Consequently, groundwater contamination is also a possibility. The risk is increased in the case of Cr VI because it is only weakly adsorbed to soil particles.

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